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APPALACHIAN FOREST EXPERIMENT STATION
ASHEVILLE, NORTH CAROLINA

LAND-USE PROBLEMS AND FOREST RESEARCH

IN THE SOUTHERN APPALACHIAN REGION

Nineteenth Annual Report and Program of the

Appalachian Forest Experiment Station

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Forest Research a Public Service

During the past five or six years many public agencies have been engaged in a combined, country-wide effort to determine and lay plans for better ways of using land. Poor land use has been proved responsible for alarming losses of fertile agricultural soil, for floods, droughts, and, as a sequence, has contributed to low living standards on farms, reduced industrial efficiency, unemployment, and other social and economic ills. In this concerted planning the forests claim a large share of attention because of the great areas they cover, their manifold uses, and the contributions they can make in mitigating social and industrial distress.

The investigations of the Appalachian Forest Experiment Station, here reported for the year 1939, are directed toward the constructive solution of these forest problems as they exist within the extremely varied conditions that characterize the different parts of the Station's territory.[1/] A brief review of these conditions will serve as a background for the descriptions of the Station's different investigative activities that follow.

The Station's territory has three broad divisions: the mountains, the Piedmont Plateau, and the Coastal Plain. The mountains are about two-thirds forested, chiefly with hardwoods. Their lumber output, during the years of heavy production, was unparalleled in quality, variety of grain and texture, and the large sizes of clear lumber obtainable from trees that often were centuries old. The mountain forest is exceedingly rich in tree species -- too rich, frequently, for the easiest management. There are more than 100 different species, 40 or 50 of which are of unquestioned industrial importance, the others often a hindrance. The original forests exist today only as scattered remnants. Most of the lumber and other forest products come from second-growth stands or from stands that have already been culled over repeatedly, and the qualities are generally much lower. Fire and the chestnut blight, as well as logging, have reduced the forest to a low ebb of productivity. Because no balance has ever existed between the growth rate and the use rate of the forests there has never been a chance to build up an adequate growing stock of thrifty timber. The development of wood-using industries is handicapped, or prevented, by unnecessarily low levels of quantity and quality, with all that this means to the region in curtailment of values from manufacture. Pure and regular water supplies, increasingly needed for industries, cities, and farms, are not being guaranteed by adequate water-storage capacities of the watersheds. Even if ample funds were provided to proceed with the cure of these ills, we would still not have the full knowledge of conditions and remedial procedures necessary to restore the high quality of forest growing-stock that the land is capable of producing, with all the additional values of water control, soil stabilization, game and fish resources, and recreational possibilities. We would need to fill many gaps in our present fund of knowledge, through forest research.

1/This territory includes the states of West Virginia, Virginia, North and South Carolina, eastern Kentucky and Tennessee, and northern Georgia.

On the Piedmont Plateau the outstanding fact about the forests is the small size and great number of individually owned tracts. While less than half the land surface is forested, the small tracts make up, in the aggregate, an immense area and so are regionally a very important source of forest products for consumption not only by the farms but also by numerous Piedmont wood-consuming industries. Individually the small tracts lack many of the advantages of management held by larger bodies of timberland under single ownership in the mountains or on the Coastal Plain; and the problem of pooling the interests of groups of owners for more efficient management is a difficult one. The small tracts have two great advantages: accessibility, and the facility with which low-grade forest materials can be sold or used. They vary tremendously in almost every respect. Many are well stocked and thrifty, some are already being efficiently managed, but many others are run down and need restorative treatment. One of the difficult problems is to prevent hardwood species from monopolizing and excluding pine reproduction on lands from which pine stands have been cut. Another is the reforestation, by natural reproduction or by planting, of large areas of abandoned agricultural land. Left idle, these lands are subject to soil wastage and gullying, and their return to productivity through the agency of tree crops would be in the interest of best land management.

On the Coastal Plain, commercial timber production is the dominant role of the forests. They cover more than 60 percent of the land surface, and fully half of the forest area is in large tracts. Pines are the most abundant and important species. They comprise over 60 percent, by lumber volume, of the total stand. Although hardwoods are important, the wood-using industries are predominantly pine-using industries. They are favored by good means of transportation to northeastern markets, by easy logging conditions, and by the abundance and rapid growth of the pines, but their future depends upon the maintenance of pine lumber and pulpwood supplies which are jeopardized by the incursion of hardwoods, by fire, and by the danger of insect attack. They consist mainly of sawmills and veneer mills using the larger timber and pulp mills consuming both large and small trees. This difference in size of the raw material imposes on timberland owners the need of choosing between long and short rotation management. Although the existing supply of pine timber seems adequate to meet current needs, it is not sufficient to permit large-scale expansion in industrial use. The recent development of the pulp and paper industry in this area indicates that new markets are available and that no effort can be spared to insure the continuance of the supplies. This effort must come in part through research. For example, on the Coastal Plain, as on the Piedmont, one of the difficult problems is the hardwood invasion of pine areas. The hardwoods themselves are coming more and more into the picture, and since they occupy about 30 percent of the forest area the problems of their best management are important.

Thus each of the three great provinces of the Station's territory has its own characteristic research needs. In the mountains these center on the restoration of run-down hardwood forests for timber supply and water control. On the Piedmont they are concerned with the improvement and extension of farm woods, the productive utilization of idle lands, and

the development of more remunerative farm forest practices. On the Coastal Plain they have to do largely with assuring continuance of supplies to fill constant, relatively steady commercial demands. In all three of these provinces it is obvious that the improvements to be expected will contribute all along the line to increased industry and a greater and more stabilized employment of labor. Some of the forest problems, of course, are economic and political; but they cannot be adequately faced until numerous technical problems, some of large scope, some of small, have been solved by forest research.

Taking Stock of our Forest Resources

Probably the most widely useful of all investigations concerned with timber supply is the systematic, nation-wide inventory of forest resources that is now being made by the Forest Survey. The Survey is supplying an authentic knowledge not only of the supplies of forest products but also of the current and prospective requirements, the drain imposed by these and other causes, the natural increase by growth, and the prospects for future adequate supplies. In the territory of the Appalachian Station the Forest Survey has been under way less than four years, but during this time the inventory has been completed for South and North Carolina (about 56 million acres) and has been started in Virginia. Nearly 65 million acres in Virginia, West Virginia, Kentucky, and Tennessee remain to be covered. Survey findings in South Carolina have been published in the form of unit releases and similar releases are now being prepared for the North Carolina Survey units.

While Forest Survey computations are not yet complete, preliminary analysis shows that the existing volume and growth of the forests in this region are much larger than previous estimates indicated. On the other hand the Survey finds that drain, particularly sawtimber drain, is also considerably greater than given in previous estimates. The comparison shows that, for these states as a whole, growth and drain are approximately equal but within the states certain areas show a decided deficit of growth while others show surpluses.

A balance of growth and drain can not be taken to indicate that a satisfactory condition exists, as growth includes the growth on all sound trees of all diameters whereas drain is largely confined to the more desirable species and to the higher quality trees. This inconsistency is not as serious in the coastal units where pines predominate as in the mountain hardwoods where successive cuttings have removed the more desirable trees, leaving stands of poor quality that frequently contain a high proportion of the less desirable species.

Throughout the area covered to date the Survey has found that forest sites are generally favorable for the production of timber crops of good quality. Few forest stands, however, have sufficient stocking to make full use of the productive capacity of the site. Pine stands on the average are

less than half stocked, and a similar condition appears to exist in hardwood stands. With more intensive fire protection and improved management practices a gradual improvement in stocking, with a consequent increase in growth, could readily be obtained.

The strategic location of North and South Carolina with relation to the great northeastern industrial region places these states in a very favorable competitive position with other timber-producing regions and assures a ready market for forest products. Lumber is being shipped by truck from North Carolina directly to construction projects in Washington and Philadelphia. Pulp mill products have short hauls by train, barge, and coastwise shipping to consuming centers.

With 60% of the land in forests, favorable sites, a wide variety of desirable species and convenient markets, this region is in an excellent position to develop its timber resources and expand its wood-using industries. Such a development would mean additional income to farmers from the sale of forest products, more employment in mills and woods, and a general improvement in economic conditions.

Research in Forest Management

The Cut-over Forests of the Mountain Region

The present condition of the mountain forests is the result of an interesting history of land use. For several generations before commercial logging began there was a more or less intensive rural occupation of the mountains. The settlers drew upon the largest and best quality trees for domestic needs. Man-caused fires and grazing prevented the adequate natural replacement of such trees. Thus when the commercial lumbermen arrived upon the scene they found, in a large part of the mountain region at least, a forest of old-growth timber, but one which no longer contained its original volume or quality. Fine as the lumber output was, it was undoubtedly less rich in high grades than would have been the really virgin timber.

Removal of this remaining old growth is now nearly complete. The general picture is one of cut-over land, varying greatly in promise, but for the most part densely stocked with shrubs and with trees of many ages. Only a relatively small proportion of the trees are sound, usable, or promising stems of desirable species. These cut-over areas, however, form a considerable part of the land on which the future productive forest of the mountains must be grown, and a knowledge of the prevailing conditions on them is therefore important as a basis for their improvement. The Station has accordingly completed an analysis of 17 such areas, widely distributed over the Station's mountain territory, and unburned since cutting. These areas were representative of different forest types, had been cut over for different periods, and none had been given any improvement treatment.

While the cut-over stands varied a great deal in quality and promise, most of them had too many poor trees, too few good trees, and too few saplings of desirable species that were free from shade. The average stand per acre was 36 timber trees (9 inches and over in diameter), 125 poles (3-9 inches in diameter), and 973 saplings (1/2 - 3 inches in diameter); but 64 percent of the poles and 47 percent of the timber trees were unsound, crooked, or limby, while 72 percent of the saplings were sprouts, or of inferior species, or both. In the absence of improvement measures, only 13 percent of the entire number of saplings had any promise for the future stand. The study presents a rough measure of the deterioration which has come about, as much through leaving poor trees as through cutting the good ones.

The results of the study emphasize that rehabilitation measures in cut-over stands constitute some of the most needed silvicultural procedures in the mountain forest types. They also indicate that although the average stand conditions do not appear promising there are appreciable acreages in very fair condition. Cultural treatment should therefore be applied only after a careful classification of cut-over lands to eliminate from any program those stands that would not be particularly benefitted. A basis for such a classification is provided by the analysis.

Improvement of Young Stands in the Mountain Region

To create a reserve of timber which will support, by its growth, a large, varied, and steady yield of forest products is the goal of forest restoration in the mountain region. To reach this goal will mean the conversion of large areas of run-down woods, understocked with desirable species. It does not imply an attempt to duplicate the original forests. Foresters believe that by the use of silvicultural methods higher or at least equally high yields can be obtained in a much shorter time and perhaps with some degree of approach to the high grades of the original forest. This at least is an efficient use of forest lands, tying in with the broad objective of a permanent supply for farm and industrial needs.

The Appalachian Station is studying the rehabilitation problem in a number of ways. One is by periodically observing and measuring the development of stands following one or another kind of treatment aimed to build up the best possible growing stock. This is ordinarily done on permanent sample plots; but the early stand improvement work done by the Civilian Conservation Corps gave a fine chance to study the results five years after treatment, on widely separated areas. The treatment given by the C.C.C. consisted of releasing from competition well-distributed saplings and young trees of desirable species so as to give them a chance to grow up into the final stand. At the end of the first five-year period, these early weedings have resulted in widespread desirable responses, according to a study recently completed by the Station. The study revealed, however, that if trees selected for release ("crop trees") are below certain minimum heights they will again become overtopped, five or ten years after treatment, by sprouts arising from the stumps of the less desirable trees removed in the original release operation. Many of the methods

used by the C.C.C. were shown to be adequate, and substitutes were suggested for those which proved ineffectual.

Weedings in young stands are justified if the cost is less than the additional timber values that ultimately result. Additional values are now available only for short periods after treatment; theoretical returns based on these short-term additional values along with generous costs of treatment show sufficient promise to justify continued research on the subject.

Seed Production - Oaks

Control over the composition of future stands, when harvest cuttings are made, involves a knowledge of the seeding characteristics of different species of trees -- the quantity and quality of the seed produced, intervals between years of heavy production, influence of size and condition of tree, etc. To supply this knowledge the Appalachian Station is conducting a study of seed production, beginning with the oaks. Seed traps are placed under 210 trees of five species of oak, and weekly counts of acorns are made during the period of production from the first week of September until about the last week in November. The quantities of acorns produced by oak trees of different species and sizes have not yet been determined, but the relative productivity of the species, based upon the proportionate total acorn yields from the sample trees, show that during the three years the rank of the five species was scarlet oak (31%), black oak (24%), white oak (22%), northern red oak (15%), and chestnut oak (8%). For all the oaks combined, more than half of the acorns were either immature or deformed, 20 percent were damaged by rodents or weevils while still on the tree, and 27 percent were apparently sound; but when the sound acorns were cut open it was found that only about 70 percent were viable. Of the total number of acorns collected for all the species only 19 percent were viable, and the species ranked chestnut oak (37%), northern red oak (25%), scarlet oak (25%), white oak (10%), and black oak (10%). Scarlet oak, the least desirable species, produced much the largest number of acorns, and its percentage of viability was high, though equalled by red oak and exceeded by chestnut oak, both of which are desirable species.

Water Sprouts

The proclivity of certain species of trees to produce epicormic branches ("water sprouts") may play a considerable part in determining the kind of treatment that can be given stands containing these species. Observations made in partially cut mountain hardwood stands show an increase in the development of these branches following the release of reserved trees. This has resulted in a considerable reduction of the clear stem length, and it is evident that it may become a significant factor in the production of high-quality second-growth hardwoods in the Southern Appalachians. The prevalence of epicormic branching was studied on released trees of several species present on a sample area cut 5 years ago. Of the original merchantable volume on this area 24 percent, or 1,400 board feet per acre, was reserved in the best trees ranging from 10 to 19 inches in diameter, breasthigh. There was considerable variation between the species

in the degree of epicormic branching. White oak was the worst, 100 percent of the reserved trees showing reduction in clear stem length. This reduction amounted to more than one 16-foot log length in 43 percent of the reserved trees. Beech was the only species that exhibited no epicormic branching. Other species, in descending order of epicormic branching, were cucumber, hickory, yellow poplar, northern red oak, and white ash. These observations point to the importance of epicormic branching in connection with different silvicultural practices, and the study will be continued in 1940.

Tree Volume Tables for Local Use

Farmers and other owners of small timber tracts are often at a disadvantage in selling their wood products to experienced buyers. This conduces to a low appreciation of woodland values and to a failure to recognize the advantage of building them up for continuous production. This, in turn, is unfortunate for any large-scale self-sustaining forest program because the farmers own more than half of the entire forest area in the Station's territory. One of a number of ways to encourage forestry practice on small tracts is to provide their owners, or their advisers, with means for more accurately valuing their standing forest products. The Station, therefore has nearly completed a series of volume tables adjusted for local application which will enable a much more accurate determination of the volumes of the small number of trees usually dealt with in farm woods than is possible by the use of the more general volume tables hitherto available. The latter give only a relatively small error when applied to estimating tree volumes on large timber tracts, but when only a few trees are concerned variation in form may cause quite wide departures from the average volume. To fit the new volume tables for local application, a measure of form is introduced, which is the ratio of the outside-bark diameter at the top of the first 16-foot log to the outside-bark diameter at breast height. After some practice diameters at the top of the first 16-foot log can be estimated quite accurately by eye, but a device to aid in making this estimate is being developed. The volume of a tree of given diameter and height is then found in the table corresponding to its ratio, or "form class". The tables were prepared in response to constant requests for local volume tables applicable to many species. The variation of form class with species and with localities is to be studied, to discover whether species can be combined and whether certain form classes are typical of various parts of the Station's territory.

Hardwood Invasion of Piedmont and Coastal Plain Pine Stands

In the Piedmont and Coastal parts of the Station's territory loblolly and shortleaf pines occupy large areas, where they are highly important as sources of supply for sawmills and pulp and paper plants. The demand for pulpwood, poles, and a number of minor products in addition to lumber has created a wood-using economy which, so far as local species are concerned, is dependent very largely upon pine stumpage. The maintenance and extension of the pines is therefore in accordance with best land use. The pines are heavy producers, growing in dense stands. Their reproduction comes in densely on abandoned agricultural lands where there are trees to

scatter seed; but since agricultural abandonment has considerably abated, the maintenance of the supply must apparently be accomplished largely by the reproduction of the pines within the forest itself when the pine timber is cut. The success of pine reproduction in the forest, however, is jeopardized over large areas by the hardwoods. The presence of numerous hardwoods in the understory of pure pine stands and their conspicuousness in the growth following logging suggest that nature tends toward stands of pure hardwoods or of mixed hardwoods and pine, rather than to pure pine.

That this tendency is widespread and important to the future of pine stands is the conclusion reached in a study of hardwood succession in pure pine stands on the eastern Piedmont Plateau, that has just been completed by the Station. While this study did not include a comparison of the merits of many-aged and even-aged management of pine, its results, in general, appear to support the latter for stands 60 or 70 years old or older, particularly in view of the mortality that may follow partial cutting in such stands. Clear cutting, of course, presupposes a pine seed supply, for which seed-producing trees will have to be left standing. Even with an abundance of pine seedlings, however, it will usually be necessary to remove a good deal of the hardwood growth where it overtops or otherwise threatens the pine seedlings selected for crop trees. Studies of weedings during the reproduction stages, therefore, are of great importance and are already in progress by the Station.

Tree Planting Experiments

The last few years have witnessed a marked increase in tree planting within the region, largely by farmers. Since much of this planting is on the poorer, less fertile soils of the farms, special care is necessary, together with a knowledge of the suitability of different tree species for planting in different environments. The Appalachian Station has therefore undertaken a study of this problem, centering the work for the present on abandoned lands in the Great Appalachian Valley of Tennessee. Within the last two years 700 experimental plots have been established in eight different experiments. The important soil types and site conditions have been sampled, and a large number of species and mixtures of species are being tested. The results of the experiments will show what species to plant on the various site conditions found on abandoned agricultural land in the Appalachian Valley of Tennessee, and will furnish an indication as to the species that can be successfully planted, under similar conditions, elsewhere in the Valley and adjacent mountain country.

An analysis of first-year survival, as shown by one of the experiments embracing 180 planted sample plots on three soil types and two aspects, has given a large number of early conclusions. For example, dolomite north and south slopes and limestone north slopes gave the best results. Limestone south and shale north slopes were intermediate, and shale south slopes by far the worst. Shortleaf pine, yellow poplar, and white pine did best on dolomite and limestone south slopes and poorest on shale south slopes. Shortleaf pine was most affected by vegetative competition; and black walnut and red oak, of which the seed, not seedlings,

were planted, showed ability to survive a very dry season.

Aside from the abandoned farm lands, little of the forest area in the region requires planting; natural reproduction is usually abundant, and the difficulty and expense of saving planted seedlings from suppression by the commonly dense shrubs and trees are too great. A notable exception is the spruce burned land high up on the mountains. Here planting is necessary, though often difficult.

The spruce burns represent most of the rather small area of truly devastated forest land in the Southern Appalachian region. Their aggregate area is not very large - perhaps 1½ million acres in all - but after the removal of the spruce, fires have largely destroyed all chance for its restoration except by planting. From 1923 through 1931 the Station established experimental plantings of 20 species of conifers on spruce lands near Mt. Mitchell (Black Mountains of North Carolina). An examination made in 1939 showed that the best results had been obtained with the native southern balsam fir. Next in order of success was the native red spruce, followed closely by Norway spruce and red pine. Seven species from the western United States, five foreign species, and one from the Northeast were complete or nearly complete failures. Three others have given indifferent results. The experiment appears to have demonstrated that for the severe conditions at these altitudes the native spruce and fir are the best for planting, with red pine also showing promise. A more extensive planting experiment has been started in the spruce type in West Virginia and North Carolina, and a total of 364 sample plots in 40 blocks have already been laid out and mapped preparatory to the planting.

Studies of existing plantations have shown which cover types may be successfully planted by present methods. Experiments have been devised to test the possibilities of establishing, by new methods, the best adapted conifers on areas now considered unplantable. Actual planting began in March, 1940.

Tree planting has great possibilities in the Piedmont region of North and South Carolina and Virginia, where there are at least a million acres of idle, abandoned agricultural land and where pine, as a crop, offers the farmers a variety of cash income possibilities. One of the important things to be done is to reduce to a minimum the cost of establishing successful young pine stands. The Station has started work on this problem in two ways: first, to determine the conditions under which nature can be depended upon to make planting unnecessary, and second, to find out whether direct seeding cannot be used successfully in place of the more expensive process of planting. Some tentative conclusions are already available, based upon studies of 43 abandoned fields on the Piedmont of the Carolinas and southern Virginia, and on experiments with seed-spots artificially sown.

Thrifty, vigorously growing shortleaf and loblolly pines more than 40 years old, distributed along at least one entire side of a field, were found to constitute a Class I seed source, although open-grown trees with

spreading crowns often are the most prolific producers. A Class II seed source may be either an inadequate number of seed trees, or their poor distribution in relation to the field, or ages of from 20 to 40 years, or unthrifty, stagnated stands. When the trees are younger than this and there are only a few of them, the seed source is Class III. With a Class I seed source, 1,000 or more pines per acre will seed into an adjacent abandoned field, usually within five years, to distances averaging about 5 chains (330 ft.), and 500 or more trees per acre will appear to distances averaging about 7 chains (460 ft.). With a Class II seed source the widths of the various density zones average much less; and Class III seed sources are entirely inadequate to produce satisfactory densities of natural stocking. Thus, without proximity to a reasonably productive seed source natural stocking in satisfactory densities cannot take place.

Class I seed sources are comparatively infrequent, particularly in the Piedmont region. Pine stands 40 years of age have usually reached merchantable size and are quickly cut so that under present conditions many abandoned fields are too far from satisfactory seed sources to be restocked satisfactorily within 5, or in some cases, even 10 years. Some natural reproduction will, of course, become established on such areas but subsequent stands will be understocked, and if allowed to develop unaided will eventually contribute products that are mostly of low grade. Artificial regeneration in such partly stocked areas is probably the best remedy, and recognition of this need will add a large area to the planting problem of the region.

Except in extreme situations, soil type, erosion, plant cover, and other site properties are of comparatively minor importance. The initial step in Nature's reclamation of a cleared abandoned field is commonly the appearance, in the first year, of horseweed, frequently accompanied by crabgrass. These are replaced, in the second year, by aster and goldenrod, and during the third and fourth years broomsedge takes possession. Meanwhile, if pine seed has been provided in sufficient quantity, young pines have been starting among the weeds and later in the grass. Three or four years after germination they emerge above the herbaceous vegetation and at five to ten years they assume complete dominance as a stand. Even on eroded areas, pines display remarkable ability to take root. They may be the first pioneers on bare galls, or come in later in the poverty grass. They can become established by natural seeding under practically all the old field soil and cover conditions found on the Piedmont except in actively eroding gullies or on the driest, exposed, and eroded knolls.

To produce nursery stock and plant fields that are not subject to natural reproduction would cost $8 or $9 an acre. Therefore the Station is making tests of direct seeding, in place, of three species of pine: shortleaf, loblolly, and Virginia. Some of the seed-spots are spring sown, some fall sown; some of them are cultivated and some not; others are mulched or sown without mulch. They are in two locations in the Piedmont region, and in two site conditions at each. Preliminary summaries of the first year's results at one of these locations show definitely that (1) fall seeding is superior to spring (early May) seeding, (2) drought is by far the most important cause of seedling mortality, (3) screens are

important for survival because of their shading effect and their protection against rodents and birds, and (4) ground treatments have markedly different effects on different sites. On an eroded site with clay soil and sparse plant cover, mulching the spots with pine litter was highly beneficial, but scarification with a mattock to a depth of about five inches did not appreciably affect germination or survival. On a comparatively uneroded site with about six inches of loamy sand topsoil covered by an open stand of broomsedge, mulching was found to be actually detrimental, but scarification of spots and covering the seeds by raking was highly beneficial. The benefits of scarification on the vegetated site probably were attributable to the removal of competition, but the unfavorable reaction to mulching is still unexplained.

Forest, Water, and Soil Relations

Water supply and soil stability are associated with each other not only as indispensible resources for life and industry but also because each is dependent upon the other and both upon the kind and condition of the vegetative cover. The Southern Appalachian mountains are in one of the two high-rainfall areas of the continental United States; water flows from them as from a gigantic rooftree. It supplies millions of city residents and hundreds of hydro-electric and manufacturing plants, often several hundred miles from the mountain region. Its regularity and purity, which should be as great as nature and man can combine to make them, are very sensitive to disturbances of the vegetation covering the sloping lands at and near the source. Studies of the relation of forests and other vegetative cover to water run-off, water storage, and soil stability are therefore very important phases of forest research.

The three phases of this broad subject to which the Appalachian Station is giving most attention at present are (1) the influence of different forest conditions upon the behavior of mountain streams, (2) practical methods of soil stabilization on roadbanks, and (3) influence of forest cover on local climate.

Forest Influences

The Forest Acquisition Act (Weeks Law) of 1911, to which we owe our present Southern Appalachian national forests, was originally based entirely upon the premise that forest conditions around the headwaters of streams somehow influence the regularity of flow, and hence affect the well-being of industries, cities, and communities all the way to the mouths of the great rivers that originate in the mountains. As a result of five years' intensive studies of more than 40 drainage areas by the Appalachian Station, it has been demonstrated that the forest is a great natural reservoir capable of holding storm water much in the same manner as do artificial structures and thereby reducing the severity of the frequent local floods and of major floods in the larger streams. But the precise nature and extent of this influence, and its practical implications, still remain in large

measure an enigma. Today, national and local land use planning for the conservation of water resources makes it imperative that these influences be determined. For example, the national Flood Control Survey, soil conservation districts, and state and county land use planning boards are faced with the need of precise measures of the relation of various land management practices to the control of stream behavior and water resources. Water conservation control is among the least understood of all fundamental problems of land use management. It has been the subject of investigation by the Appalachian Station over a period of years, with the following major results:

1. The seasonal storage capacity of small forested drainage areas has actually been measured. Tentative results also indicate that it may be possible to determine the relative storage capacity of a forested area for any month in the year, thus enabling predictions of dangerous flood conditions when latent storage capacities have been reached. Similarly it may be possible to predict drought conditions many months in advance. Such predictions are of obvious value in connection with municipal water supplies.

2. Other completed studies have cleared up questions as to the behavior of small streams in forested areas, indicating that in many instances the relatively slight rises of forest streams are due to direct channel interception of precipitation and not to any form of overland storm flow. These determinations have a bearing upon various conservation problems in land management.

3. From results already obtained it has become possible to determine practical coefficients of storm runoff from different land management types and from forests on different soil types. Such coefficients have already been worked out and applied in practical flood control programs.

The studies that have led to the above results, as well as to constructive conclusions in a number of other directions, have been made on watersheds located in the three major rainfall zones of the mountains. One of these areas -- the Station's Coweeta Experimental Forest -- is in the highest rainfall zone, and the forest is characteristic of the most valuable protection type now under national forest administration. Here, 26 tributaries of two forks of a small but constantly flowing stream are under systematic flow-measurement by means of weirs and gauges, while a large number of rain-gauges (both standard and intensity) are well distributed over the 4,000 acres in the area. The two other areas have smaller numbers of similar installations.

The preliminary work on a majority of the measured watersheds is to determine the normal behavior of the streams under the existing vegetative conditions at their heads, and under the varying seasonal and annual climatic conditions of a five-year period. For 15 of the drainages the basic data on precipitation and stream discharge have already been compiled for the five-year period. This has incidentally furnished the coefficients, referred to above, of storm runoff for a number of land-use

types. At the expiration of the five-year period, the watersheds are to be subjected to different kinds of forest land management. The application of these various land use practices was started in 1939 on some of the 15 watersheds that had been under observation for 5 years. It will be extended to others as rapidly as the normal, or "standard", relations of runoff and precipitation have been established, and from then on the continued records are expected to yield conclusive data as to the effects of the different kinds of treatment.

Practical Methods of Soil Stabilization on Roadbanks

Throughout the Station's territory soil-depleting agriculture has created large aggregate areas of submarginal agricultural land. On sloping land soil erosion is rapid because of open winters marked by repeated freezing and thawing and followed by heavy rains in late spring. Productive as well as unproductive cleared lands are likely to suffer from an erosion that not only wastes their substance but also washes loads of silt into streams and reservoirs. During the last seven years a large additional source of eroded soil has been created by the cuts and fills along thousands of miles of roads under the emergency programs.

The roadbank erosion problem is an aesthetic as well as an economic one. The unattractiveness of the bare soil exposures extending mile after mile along the roads has been the cause of much unfavorable comment by motorists. Fishermen and those needing clear water for domestic and commercial purposes have complained that streams were muddied by soil washing from road cuts and fills. Road engineers find that sloughing of material from raw banks increases maintenance costs.

While some moist and fertile roadbanks have reseeded naturally and promptly, this is not the case with most of the large cut banks and some fills, and it is not a simple task to get vegetation established on them. Many of them are raw, dry, infertile, and exceedingly poor seedbeds for plants of any description. Alternate freezing and thawing make the soil unstable and uproot plants that have started. The soil loosened by frost action is easily washed off the bank by rains. A number of different methods of stabilizing the soil by planting have been tried, but most of them are too expensive to be applied economically to the many hundreds of miles of roads that need bank fixation.

The Station's experiments in roadbank fixation have led to the conclusion that the simplest, cheapest, and only sure method is first to reduce mechanical action to a minimum by rounding off the tops of the slopes, reducing the steepness as much as possible and minimizing frost heaving; and second, to provide an adequate seedbed, including soil fertility, moisture, and a supply of seed of the native vegetation, by applying a mulch of weeds, straw, grass, etc., to the raw slopes. If properly done, Nature, in nearly every instance, will do the rest. The local briars and weeds that seed in will blend the roadsides into the natural landscape and at the same time provide the needed soil stabilization.

The two general methods developed by the Station are: (1) staked weed mulches, for use in open country and wherever weeds can be obtained readily; and (2) staked brush and litter mulches, to be used in heavily forested areas where weeds are not available. The first named method is generally the easier of application, but both have proved feasible on extensive projects and have given satisfactory stabilization. The purpose of the staking is to keep the mulch from slipping down the bank or from being blown about by the wind. Several hundred miles of road have been successfully treated, and the Station has issued a circular containing full instructions for applying the method.

Influence of Forest Cover on Local Climate

The often repeated claim that forests have a marked influence upon the local climate -- that deforestation is responsible for the waste or desert conditions in parts of northern Africa, Persia, China, and India -- has been vigorously questioned for lack of scientific proof that the removal of the forest was the cause of the climatic changes. Such changes, it is pointed out, are constantly taking place for many reasons, and may themselves be responsible for the absence of forests today. The question is important within the Appalachian Station's territory with its generally high temperatures, long growing season, extreme evaporation, and rapid transpiration. On the Piedmont Plateau, where about half the land has been cleared, it is possible, for example, that desiccation has proceeded to the extent to affecting the water economy of the region. In badly depleted areas erosion is active; many streams show frequent flooding; and if, as is believed, wind velocities have increased, this must have had a progressively desiccating effect upon the land surface.

An excellent opportunity for studying the problem of forest denudation and local climates is presented in the Copper Basin of Polk County, Tennessee. This is one of the rare instances where it is possible to compare the climates of similar contiguous areas of large size, differing only in the presence or absence of forest. Surrounding a 7,000 acre center which has been completely denuded by smelter fumes there is, first, a 12,000 acre zone which supports perennial grasses; this is surrounded, in turn, by a hardwood forest of about the same composition as that which originally occupied the basin. For five years the Appalachian Station has been making coincident records in the three zones. These records show that in both winter and summer the average daily temperatures dropped 3 or 4 degrees F. lower in the forest than in the denuded zone, and did not generally rise as high. Average wind velocity was 7 to 10 times as great in the denuded zone in winter, and 34 to 40 times as great in summer. Evaporation was twice as great in winter and 7 times as great in summer. These differences may be explained as associated with the insulating and mechanical effect of the trees, but it is quite a different matter to explain the observed differences in precipitation which throughout the entire period of observation have been consistently higher in the forested than in the denuded zones. These differences in local climate are, of course, associated with complete denudation. It has become evident, however, that definite climatic changes also take place when the forest is only partially

removed, as is the case under various silvicultural practices.

Solving the Flood Problem Through Land Management

Relations between stream behavior and the management, or mismanagement, of watershed lands are recognized in the Flood Control Survey provided for by Congress in 1936. The watershed surveys, which are a first step in any broad program of watershed improvement, are now engaging the cooperative activities of several federal bureaus. The Appalachian Station took an active part in this work during the past year, in a territory of about 175,000 square miles in the states of Pennsylvania, Maryland, Virginia, West Virginia, Kentucky, North Carolina, South Carolina, Tennessee, Georgia, and Alabama.

The watersheds studied are those for which existing records suggest the possibility of a serious flood hazard. Preliminary examinations are made of these watersheds to determine the nature, location, and contributing factors of the hazard, and the physical and economic possibilities for a control program. If the preliminary examination verifies the seriousness of the hazard and justifies its control, a detailed survey of the watershed is made, and definite plans and measures for flood control operations by the Department of Agriculture are drawn up. The survey also furnishes an evaluation of the effects of the proposed plan upon the economy and resources of the basin, and a justification for the remedial plan based on carefully estimated costs and benefits. The plan distributes the proposed work and its costs among the different participating agencies.

In the correlated plans for preliminary examinations and surveys the Station is assigned primary responsibility for Atlantic coastal streams from the Potomac River in Pennsylvania, Maryland, West Virginia, and Virginia on the north; through Virginia to the Roanoke River in Virginia and North Carolina on the south; and for Ohio River tributary streams, including the Little Kanawha, Kanawha, Guyandot, Twelvepole, Big Sandy, and Tennessee Rivers and their tributaries. In addition, the Station cooperates in preliminary examinations and surveys on the Atlantic coastal streams in North and South Carolina. During the past year the Station completed a survey on the Coosa River in northern Georgia; began others, which are now in progress, on the Potomac and Peedee Rivers; and completed preliminary examinations of the New River and tributaries and of the Santee-Cooper Rivers.

The work so far done thoroughly justifies these surveys. It shows that the surveys, with the operations to which they lead, can be outstanding contributions to the control of floods and to a better utilization of our water and land resources. In addition to showing what can be accomplished in flood control through conservation and upstream engineering these studies indicate that on some watersheds, where stream synchronization is an important factor in the formation of high flood crests, more real flood alleviation may be obtained from conservation measures tending

to change the synchronizations of the streams than from measures to reduce the storm run-off. Maximum benefits will result when the remedial measures are planned as to type, location, and timing of installation so as not only to cause a maximum reduction in the amount of storm run-off but also to prevent the synchronized movement of flood crests within the drainage system. Flood control surveys further present one of the best opportunities yet offered for agencies and persons interested in the control of floods and better utilization of water and land resources to meet on a common ground and discuss, correlate, and point up their programs toward better watershed management, in the interest of the maximum public and private good from all work done.

The Forest Fire Problem

In the mountains, repeated burning is more responsible than any other factor for the run-down condition of the hardwood forests. Understocking, the principal deficiency in the Piedmont and Coastal Plain stands, is largely the result of uncontrolled fires. The menace of fire to the security of the resources upon which wood-using industries depend, coupled with an intangible but very great loss through reduction of water storage conditions at the heads of streams, destruction of fish, game, and recreational values, clearly demonstrate the need of thoroughly adequate protection. For the Station's territory as a whole, about 1 acre in 20 is burned annually, and for the half of the territory without organized protection about 1 acre in every 10. This is no reflection upon the splendid results achieved by organized protection agencies; funds required to reduce fires to a satisfactory minimum are simply not available.

Fire research at the Appalachian Station is accordingly aimed toward finding out how much fire protection and control is justified and to produce guides for the efficient use of what moneys are available -- to "stretch the fire protection dollar".

The obscure nature of fire damage to hardwood trees, which sprout readily and soon cover up external evidences of injury, has led to the common belief that fires in hardwood forests do little harm. The fallacy of this belief is shown by the results of a study of tree death and decay cull following fires in hardwood stands which the Station made during the past year. From a method that was devised for appraising mortality and cull damage, preliminary indications are that the loss in dollars and cents is two or three times greater than was previously supposed. Facts and figures like these are immediately useful in two ways: (1) indefinite fire prevention publicity can be strengthened and the man-caused fires resulting from ignorance (99 percent of each year's fires are man-caused) can be reduced; (2) dollar and cent damages, accurately determined, are essential if fire protection is ever placed upon an economically sound basis. It is poor business to spend 50 dollars to save 10; but we are not sure yet how far we can go before the most profitable expenditure is reached. The damages recently determined provide the first facts upon

which to base such calculations; and even when these tangible losses are fully determined there still remains the more complicated problem of measuring in dollars the damage to watershed, game, and recreational values.

As an aid to forest administrators in judging the chances of fires starting, the rapidity of their spread, and the difficulty of control, the Station has devised a system of fire danger measurement based on four key factors. These factors are fuel moisture, wind, condition of vegetation, and season of the year. Special instruments have been devised to measure fuel moisture, and other factors are measured with standard devices. Measurements of the key factors are obtained at a network of fire danger stations, one station for every 150,000 acres of protected land in the mountains and one for every 300,000 acres in level and rolling country. In making a reading of the existing and pending fire danger, the values currently determined at a station are integrated by a specially devised "forest fire danger meter", which shows at a glance the fire danger class (1 to 5, in ascending order of fire danger) corresponding to the integrated observations. The system is not intended to displace, but to aid, the judgment of experienced fire executives. It has the great advantage that estimates of fire danger in widely separate parts of the region and by different individuals are strictly comparable. One man each from the eastern and southern national forest administrative regions has been detailed to the Station to assume the major task of installing and checking the fire danger stations. In this work the Station cooperates closely with the U. S. Weather Bureau, whose fire weather service in the Station's territory is described in the following section of this report.

The Station's leading accomplishment in fire research during the past year has been the extension of this system, with the development of a new danger meter, to the Coastal Plain forest types, and the beginning of a widescale field test of this and the mountain-type meter. Approximately 225 stations, divided between 9 state organizations, 25 national parks and memorials, 34 national forests or purchase units, and several other miscellaneous federal and private fire protection agencies are now rating danger with these meters. A detailed publication on the measurement of fire danger and its application in the entire field of fire protection was prepared and has served as a useful handbook for fire control officials. The system has been established in the New England hurricane area, and under the direction of the Appalachian Station has contributed materially to the successful functioning of state and federal organizations in that section during one of the driest seasons on record.

Among other accomplishments in the Station's fire research in 1939 have been refinements in methods of selecting forest fire lookout men, through the development of a new eyesight test. This test, inexpensive, simple, and accurate, has proved superior to other tests now in use.

Fire Weather Service[2/]

Among the factors which favor the start of forest fires and influence their behavior, weather plays a dominant role. The ease with which fires start is largely a function of dryness of the lighter fuels, which in turn is dependent upon humidity, occurrence of precipitation, wind velocity, etc. Likewise the rate of spread and resistance to control varies with humidity, temperature and wind velocity. This, of course, holds true whether or not efforts are made to control fires; but when large sums of money are being spent to prevent or suppress them, knowledge of the prevailing and anticipated weather conditions assumes major importance. Furthermore, recent developments in the technique of fighting fires, and increasing mobility of forces, make it more than ever necessary that full account be taken of expected weather conditions in making plans for suppression.

The Weather Bureau's fire weather service has been developed to meet this obvious need for forecasts designed especially to fit the needs of forest protection agencies. Although this service has been in operation for many years in the far western states, it was inaugurated as a specific program in the Southern Appalachian Region only in 1932. The headquarters office is in Asheville, N. C., and territory served includes the forested area of West Virginia, western Virginia, eastern portions of Kentucky and Tennessee, northern Georgia, and mountainous sections of the Carolinas.

Briefly, the method of operation in this district is as follows: Through the excellent cooperation of the U. S. Forest Service, state forest services, and numerous public spirited citizens, some 60 forest substations have been established. At each of these, three observations are made daily of temperature, humidity, precipitation, state of weather, wind direction and velocity, and in some instances kind of clouds. These observations are carefully recorded to become part of the forest climatology of the region, and to serve as a basis for research. During the spring and fall fire seasons, a selected list of these sub-stations forward telegraphic or telephoned reports each morning to the Weather Bureau in Asheville. Here the fire weather forecaster enters the data on synoptic charts and uses them as a basis for localizing and adapting the general forecasts prepared from the main country-wide synoptic collection.

Fire weather forecasts, being specialized so as to meet the needs of fire fighters, include predictions of wind direction, wind velocity, and humidity, in addition to the familiar weather and temperature forecasts. Furthermore, they are prepared with the local topography and forest conditions in mind, and as a result are localized to fit individual national forests, or even ranger districts. This calls for an intimate knowledge of topography in altering the prevailing regional weather predictions. When conditions warrant, it is possible to issue general outlooks for as much as 5 days in advance, thus allowing protection agencies to make longer range plans. Forecasts are given as wide distribution as available funds permit by telegraph, telephone, newspapers and radio.

2/Prepared by L. T. Pierce, U. S. Weather Bureau

In the future, it is expected that fire weather forecasts will serve as an efficient basis for making predictions of fire danger class. It will be practicable to issue specific predictions of those elements which are used in determining the class of fire day, and with the cooperation of the fire danger specialist to predict actual variations in moisture content of forest fuels.

Controlling Tree Diseases[3/]

The pathological problems of the Appalachian region might be classified under the following headings: estimating defect, providing measures to reduce defect, predicting the behavior of epidemics, providing direct control measures for special diseases, responding to requests for information, and extension and educational work particularly to the C.C.C. A glance at the background of some of these problems together with recent advances including those of the past year will give an idea of the function of pathology research in this highly complex and heterogeneous region.

Intelligent timber marking on sale areas or in timber stand improvement work and timber cruising requires a knowledge of estimating defect. This has been a matter almost entirely of individual judgment until recent pathology studies provided data with which to judge defects. A study of fire-scarring in hardwoods has provided a means of estimating the volume of butt rot from the width of the scar and the number of years since the fire. For example, 50 years after a fire 5-inch wounds had an average of 4 board feet of cull behind them, 15-inch wounds 70 board feet, and 30-inch wounds 156 board feet of cull. Another study made during the past year has led to a means of estimating the volume of top rot from the number of rotten stubs, healed knots, and injuries on the trunk. The trees were divided into five risk classes depending upon the number of stubs and other wounds. The best trees were called A-risk and these had an average of 3 board feet of rot in the upper part of the trunk. These trees had no large rotten stubs, surface wounds, or holes and less than 3 blind knots. The poorest trees were the E-risks, which had an average of 218 board feet of top rot. These had four or more large rotten stubs or eight or more blind knots on the trunk.

The defective condition of the trees in much of our upland hardwood forest focuses the attention of the provident timberland owner on improving the condition of his woods in the course of logging, fuel-wood cutting, etc. Fire, of course, must be kept out, to avoid not only the killing of trees but also fire-scarring and subsequent butt rot. In unburned sprout-oak stands butt rot is still an important factor. Recent studies show that about one-fourth of the stump-sprout oaks over a vast area including the Virginias, Maryland, Pennsylvania and parts of other states are butt-rotted as a result of the transmission of decay from the parent stump to

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3/Prepared by G. H. Hepting, Bureau of Plant Industry.

the attached sprouts. We have found that most of this rot can be avoided by encouraging seedlings, sprouts from small stumps, and sprouts that arose close to ground level, rather than higher on the stump. New research has also shown that sprouts of high origin usually attain dominance over the low-origin sprouts on the same stump and must be cut out early if the low ones are to be brought through. Other new work bearing on reducing defects has shown that released yellow poplar will resist Nectria canker and rapidly throw off existing cankers, while release has little or no effect on the reaction of white oak and black walnut to canker.

A disconcertingly large number of new epidemic tree diseases have appeared in the United States in the past quarter century. The hardwood forests of the Appalachians received a staggering blow when the chestnut, representing 40 percent of its sawtimber volume, was killed. Now wilt diseases threaten destruction of persimmon and mimosa trees, and a rapid deterioration of shortleaf pine in parts of the Piedmont, is causing concern. Detailed investigations of the mimosa wilt during the past year showed: (1) that the disease is scattered from Richmond, Virginia, to La Grange, Georgia, and is spreading rapidly; (2) that it is caused by a soil-borne species of Fusarium; and (3) that our native leguminous trees of this region are not susceptible to attack. Investigations of this type, on epidemic diseases, help us predict their behavior. In a timber species, such as shortleaf pine, this will influence cutting operations, mill locations and amortization, and general silvicultural policy. In a shade tree species such information will affect the choice of species for planting and the type of care to be given certain species.

Direct pathology service to the C.C.C. has been maintained by a technician whose work involves giving illustrated lectures on tree diseases at camps, and examining the forests for disease problems that may influence the woods work of the Corps. During the past year such visits were made to almost all of the national forest camps in the region and most of the national park and state camps engaged in woods work. In addition reports have been issued on the effects of timber stand improvement work on subsequent disease and damage, based upon examination of stands worked during the first two years of operation of the C.C.C., and on methods of pruning hardwoods to keep decay at a minimum.

Controlling Insects that Damage Trees and Forest Products[4/]

If the annual damage done by insects to forests and forest products could be figured in dollars and cents, it probably would be appalling. One hundred millions of dollars per year is a recent estimate. Considerable of this loss is suffered within the territory of the Appalachian Station. It is important not only to the timberland owner and operator; every individual, whether or not he is mindful of it, feels its effect in

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4/ Prepared by B. H. Wilford, Bureau of Entomology and Plant Quarantine.

one way or another. Often it is of very direct concern to him.

Insect attacks on the forest begin when the tree seeds are produced, continue on through the periods of the trees' growth, and to the time when the trees have reached maturity and are felled. But insects do not stop their destruction of timber at the edge of the forest. In the sawmill, the lumber yard, the manufacturing plant, and as finished products, woods are subject to attack and serious damage. It is the duty and aim of the forest entomologist to take account of and estimate damages caused by insects, to recognize new and possibly serious pests, to determine ways and means of reducing or preventing the losses caused by them, and to make generally available the information thus obtained. Some of the contributions of this nature made by the office of Forest Insect Investigations in cooperation with the Appalachian Forest Experiment Station are briefly summarized in the following paragraphs.

Studies directed toward the control of white grubs in forest nurseries, entailing intensive investigations, have revealed that grubs can be barred effectively from the seedbeds by mechanical means and that infestations can be controlled satisfactorily by treatments with carbon disulphide.

Recently an insect, new as a forest pest but for several years destructive to vegetable crops, was found seriously damaging red cedar seedlings in nursery beds. Studies revealed that while the infestations can be controlled with applications of carbon disulphide, simple alterations in nursery practice afford complete protection by preventing infestation.

In pine stands of the Southeast the sporadic ravages of bark beetles -- of the southern pine beetle in particular -- result in serious financial losses. These losses are direct, incident to the death of the trees and the staining of the wood, and indirect, due to the upsetting of operation and management plans through the destruction of timber intended for future use, the necessity of undertaking control measures, and the necessary halt in going logging operations. Although specific outbreaks of bark beetles are thus far unpredictable, meteorological records suggest direct correlations between drought conditions and bark beetle outbreaks. No correlation has been found between logging operations and insect outbreaks.

Chemical injections and sprays tested for the control of bark beetles may prove feasible for general practice. The use of injected or sprayed chemicals on healthy trees as measures for preventing attacks by bark beetles and other destructive insects show promise of effectiveness.

The rapid losses suffered by untreated nondurable woods used in contact with the ground and in rustic construction have precluded the use of such materials almost entirely. But methods of impregnating trees and posts with water soluble preservatives have been devised which permit ready and inexpensive treatment and thereby the use of otherwise nondurable woods for such purposes.

Termites, the "white ants" feared by the public and classified by

many eradicators of household and general pests as one of the century's worst threats to property and life, have claimed a goodly share of the investigations. To find methods for preventing their entry into wooden structures, dwellings especially, chemical and structural tests have been made, together with tests of metal shields. While termites are sometimes very destructive they can usually be controlled by home remedies. For temporary control chemicals are effective in some instances, but for permanent control it may be necessary to make structural alterations; and sometimes a combination of chemical treatment with structural change is advisable.

Powder-post beetles, less publicized than termites but equally destructive, damage seasoned wood, from dead trees in the forest to the best piece of furniture in the house. Investigations are needed to find means for control and prevention. No seasoned wood is known to be resistant to damage by these insects, unless it is chemically treated. Tests are showing that chemicals hold considerable promise for control; tests of logging at different times of the year and of methods of seasoning are indicating possible means of prevention.

In addition to carrying on these specific problem studies, attention is given to answering innumerable requests for information on miscellaneous destructive and beneficial forest and forest product insects of the Appalachian region.

SUMMARY OF PLANS FOR 1940

Forest Management Research

(1) Complete the loblolly pine pulpwood cutting studies now half done. Analyze the results of last year's work on accelerated growth, mortality, and development of epicormic sprouts following partial cutting in mountain hardwood and loblolly pine types.

(2) Reexamine weeding, liberation, and pruning experimental plots in mountain hardwood types.

(3) Continue seed production studies. Prepare working plans for new studies of silvicultural requirements for germination and early survival in important species.

(4) Obtain growth and survival records for the eight planting experiments in the Appalachian Valley. Complete experimental planting in spruce type.

(5) Analyze results of direct seeding experiments in the Piedmont. Make more extensive tests of most promising methods.

(6) Make probably last examination of loblolly pine heredity plantation near Bonneau, South Carolina, to be flooded by backwaters of Santee-Cooper dam.

(7) Begin preparation of handbooks of non-normal yield tables for short-leaf and Virginia pine.

(8) Complete 5th-year examination of permanent growth plots in mountain hardwood types.

(9) Complete form class volume tables for important timber species of the region, top volume tables for oaks, and converting factors for oak cordwood.

(10) Analyze fire reports of the last three years for the purpose of revising fuel type classification. Analyze fuel type data collected for past three years.

(11) Continue field work on mortality and cull resulting from fire. Complete preparation of damage appraisal tables. Continue study of effect of fire on diameter growth. Make preliminary analysis of fire effect records for coastal plain controlled-burning plots.

(12) Continue check of mountain type danger meter and coastal plain meter, particularly as applying to state organizations. Analyze fire reports to establish rates of spread by danger classes. Continue study of fire weather, as influenced by altitude and aspect. Complete investigations of relation of radiation and wind to fuel moisture. Continue theoretical considerations of fundamentals of combustion and inflammability.

Definitely scheduled are 38 technical publications giving the results obtained in work completed or continued.

Forest Influences Research

(1) Establish better indices of evaporation and transpiration for drainage area studies on the Coweeta Experimental Forest. If Copper Basin Station is continued, expand work to include meteorological records in tree plantations.

(2) Begin the change of cover conditions on certain of the 18 standardized watersheds on the Coweeta Experimental Forest according to a plan to be prepared following the Influences conference.

(3) Determine plant survival on soil stabilization test areas seeded and fertilized in 1939. Make additional fertilizer tests using calcium metaphosphate. Probably considerable time will be spent on technical advisory jobs.

(4) Continue studies of crown interception and ground water.

Definitely scheduled are 7 technical publications giving the results obtained in work completed or continued.

Flood Control Surveys

(1) Complete preliminary examination reports for the Big Sandy and Little Kanawha watersheds. Begin work on the James and Tennessee watersheds.

(2) Complete detail survey of the Pee Dee and continue on the Potomac watershed. Complete survey work outline for the New River. Additional work depends on action taken by the Flood Control Advisory Committee.

Forest Survey

(1) Complete as much of field survey of Virginia as available funds permit.

(2) Make growth computations for the South Carolina units for years 1937 and 1938, North Carolina units for 1938, and for Virginia as rapidly as field progress permits.

(3) Edit over 3,000 census forms for North and South Carolina. Bring drain data for North and South Carolina up to date.

(4) Compile consolidated tables of area and volume for North Carolina and for surveyed Virginia units.

The South Carolina State report and the remaining North Carolina unit reports will be completed.

P E R S O N N E L

General Administration

R. E. McArdle	Director
R. M. Nelson	Assistant Director
C. W. Mills	Administrative Assistant
G. M. Foltz	Senior Clerk
J. Laxton	Senior Clerk
W. A. Nesbitt	Junior Forester
E. C. Krogfoss	Clerk-Stenographer
M. P. Gudger	Senior Stenographer
A. F. Powell	Asst. Clerk-Stenographer (1/2 time)
I. M. Powell	Asst. Clerk-Stenographer
H. P. Boggs	Asst. Engineering Draftsman
F. L. Barber	Under Clerk-Typist
J. R. Lloyd	Under Clerk-Typist
D. Brown	Laborer

Forest Management Research

L. I. Barrett	Senior Silviculturist
E. H. Frothingham	Senior Silviculturist
G. M. Jemison	Forester
J. H. Buell	Associate Forester
L. E. Chaiken	Associate Forester
*N. E. Hawes	Assistant Forester
L. S. Minckler	Assistant Forester
G. M. Byram	Junior Meteorologist
W. E. McQuilkin	Jr. Forest Ecologist
A. A. Downs	Junior Forester
J. J. Keetch	Junior Forester
F. M. Wehry	Asst. Clerk-Stenographer
E. L. Dawson	Jr. Statistical Clerk

Forest Survey

E. V. Roberts	Senior Forester
J. W. Cruikshank	Asso. Forest Economist
G. E. Morrill	Asso. Forest Economist
**E. B. Faulks	Asso. Forest Economist
W. T. Hicks	Associate Economist
T. C. Evans	Assistant Forester
J. Carow	Field Assistant
F. R. Lynn	Asst. Clerk-Stenographer

*Transferred during 1939.
**Deceased.

Forest Influences Research

C. R. Hursh	Sr. Forest Ecologist
*R. A. Hertzler	Assistant Engineer
H. C. Creasman	Assistant to Technician
I. Willoughby	Jr. Statistical Clerk
C. E. Russ	Under Clerk-Typist

Flood Control Surveys

H. J. Loughead	Conservationist
A. L. Richey	Forester
*S. D. Beichler	Associate Forester
H. C. Woster	Asso. Hydraulic Engineer
M. M. Bryan	Assistant Forester
J. P. Clawson	Associate Engineer
R. D. Williams	Junior Forester
J. E. Keefus	Junior Forester
O. K. Krogfoss	Junior Forester
W. J. Grady	Junior Forester
C. K. Steele	Senior Clerk
C. W. Cromwell	Sr. Engineering Draftsman
D. A. Anderson	Asst. Clerk-Stenographer
H. Thornton	Asst. Clerk-Stenographer
M. Turnipseed	Asst. Statistical Clerk
*H. Steiner	Jr. Statistical Clerk
L. A. Wood	Jr. Calculating Machine Operator

C O O P E R A T O R S

Bureau of Entomology and Plant Quarantine
Division of Forest Insect Investigations

B. H. Wilford	Associate Entomologist
W. L. Baker	Assistant Entomologist
R. J. Kowal	Junior Entomologist
A. F. Powell	Asst. Clerk-Stenographer (1/2 time)

Bureau of Plant Industry
Division of Forest Pathology

G. H. Hepting	Associate Pathologist
E. R. Roth	Junior Pathologist

*Transferred during 1938.

The above list does not include technical and clerical employees paid from emergency funds.

PUBLICATIONS
BY
MEMBERS OF THE STAFF (INCLUDING COOPERATORS)

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RS - AP
SILVICULTURE
Harvest Cuttings

January 1, 1940

PROJECT STATUS SHEET

Harvest Cuttings

Field division: Forest management research.
Work project: Silviculture.
Line project: Harvest cuttings.
Purpose: To determine the methods of harvesting merchantable products that will provide the greatest sustained income.
Review of past work: Examination of cutover land and establishment of controlled experiments have shown that although Appalachian hardwood types can be perpetuated either by even-aged or all-aged methods, the latter is most feasible for all types except those containing high proportions of hemlock. Stands of hemlock left after partial cutting frequently show high mortality. Clear-cutting of hemlock by natural groups is recommended. Even-aged management of southern pines through some form of clear-cutting of mature stands is preferable to many-aged management in the eastern coast and Piedmont regions. Partial cutting in mature loblolly pine sawtimber particularly, frequently is followed by heavy mortality in residual stands. Attempts to produce many-aged stands of southern pine through partial cutting is often inimical to establishment of pine reproduction and favorable to invasion by hardwoods.
Accomplishments during past year: Data from 5-10-year old experiments in partial cuttings of Appalachian hardwood and loblolly pine types were collected for the primary purposes of evaluating accelerated growth and mortality of residual stands in both types, and in addition for the hardwoods, reduction of clear stem length due to epicormic sprout development. A series of experiments was established to test the best methods of thinning second-growth cove-hardwood stands for intermediate products, such as pulpwood, fuelwood and handle stock. Another series of pulpwood thinnings was half completed in second-growth loblolly pine to test the existing cutting rules adopted by the Southeastern Pulpwood Association and to compare the returns from short and long rotation crops of this species.
Plans for next year: Complete the loblolly pine pulpwood cutting studies now half done. Analyze and prepare for publication the results of last year's work on accelerated growth, mortality, and development of epicormic sprouts following partial cutting in mountain hardwood and loblolly pine types.
Date of completion: Project as a whole - continuous. First results from loblolly pine pulpwood cuttings will deal with the effect of silvicultural method on costs of felling and bucking loblolly pine pulpwood and the reproducing efficiency of various numbers of seed trees. The former will be available in 1940 and the latter in 1942. Results of an analysis of cutover areas in the Appalachian hardwood types will be completed in 1940.
Assignment: L. E. Chaiken, E. H. Frothingham, A. A. Downs.

RS - AP
SILVICULTURE
Stand Improvement

January 1, 1940

PROJECT STATUS SHEET

Stand Improvement

Field division: Forest management research.
Work project: Silviculture.
Line project: Stand improvement.
Purpose: To develop standards for ultimately profitable improvement measures that will maintain or improve the growth rate and stem and stand quality of juvenile stands and run-down forests of older age classes.
Review of past work: Experiments testing four methods of weeding three of the most valuable hardwood species have been established. Less intensive work has been done on three additional species in the mountain types. Response to treatment during first two years varies widely with species and ranges from a marked increase in growth of sugar maple the first year to an actual reduction in first year height growth for yellow poplar. White pine required three years to show response. White oak failed to respond for two years.

Live pruning of white pine should not remove over 20% of living branch whorls if growth rate is to be maintained.

Accomplishments during past year: Surveys of weedings made by C.C.C. showed that at the end of 5 years, all 7 of the important mountain species studied had made significant improvement in height or diameter growth or both. Results of this study include recommendations for the conduct of weeding operations. Among these are that dangers of early suppression of crop trees by sprouts arising from the weeding can be avoided by using the following minimum heights in choosing crop trees; 5 feet for yellow poplar, chestnut oak and sugar maple; 10 feet for shortleaf pine, white pine and red spruce; 15 feet for white oak.
Plans for next year: Maintenance and reexamination of existing permanent weeding, liberation and pruning experiments in mountain species. Completion of report for publication on survey of weedings done by C.C.C.
Date of completion: First results on best methods of weeding to maintain or improve growth rate of mountain hardwood species to be available in 1943. Best methods suited to production of high quality stems available in 1948.
Assignment: A. A. Downs, J. H. Buell, E. H. Frothingham.

RS - AP
SILVICULTURE
Silvics

January 1, 1940

PROJECT STATUS SHEET

Silvics

Field division: Forest management research.
Work project: Silviculture.
Line project: Silvics.
Purpose: To determine basic factors essential to establishment and early survival of important timber species; to detect and report ecological trends important in forest management.
Review of past work: Studies of seed production in loblolly pine have proved that significant quantities of seed fall throughout the period October through March. During a good seed year, more than 250,000 seed per acre were found in a clear-cut strip adjacent to a mature stand of loblolly pine sawtimber. At the end of three years, somewhat over 950 seedlings per acre had become established from this seeding.

Studies of acorn crops in mountain types for four successive years have shown complete consumption of crops in areas of high game population by December 15.

Accomplishments during past year: Ecological studies in the Piedmont region have shown aggressive invasion of hardwoods into pure pine stands, creating conditions inimical to maintenance of high proportions of pine in future stands. A manuscript dealing with this ecological trend has been submitted for publication.

Experiments dealing with the seed-producing capacity of loblolly pine stands and of different tree classes of five species of oak have been maintained.

Plans for next year: Maintenance and reexamination of existing seed production studies. Preparation of working plans for new work to determine silvicultural requirements in important species for germination and early survival.
Date of completion: Project is continuous. Comparative seed production of various oak tree classes to be available by 1943.

Additional results from seed-producing capacity of mature loblolly pine to be available in 1942.

Assignment: W. E. McQuilkin.

RS - AP
REGENERATION
Planting

January 1, 1940

PROJECT STATUS SHEET

Planting

Field division: Forest management research.
Work project: Regeneration.
Line project: Planting.
Purpose: To determine the best planting methods and the species best adapted to various sub-regions within the Station's territory.
Review of past work: First exploratory planting experiments were begun in 1923 in the cut-over spruce type of the mountain region. Large numbers of coniferous species, including exotics, were established in this type.

Description and classification of plantations established on the Biltmore Estate in Buncombe County, North Carolina, were completed and published as U. S. Dept. Agric. Miscellaneous Publication #61, 1930.

In 1938, eight large-scale planting experiments dealing with problems of abandoned lands in the Appalachian Valley were started in cooperation with the Tennessee Valley Authority.

Reconnaissance and analysis of the planting problems in the red spruce type was completed and an intensive study of various methods of direct seeding by spots was begun in the Piedmont region.

Tests of various storage methods for loblolly pine seed showed that best nursery results follow storage for three months in moist media at temperatures of 32-40° F.

Accomplishments during past year: Establishment of the cooperative planting experiments in the Appalachian Valley was completed and first-year survival and growth records for the 1939 planting, and second-year records for the 1938 planting were obtained. Analysis of first-year survival records showed that for six of the native valuable timber species, dolomite soils were best, limestone soils second best, and shale soils poorest. Significant variations in first-year survival as between north and south slopes were discovered for some species. These and other conclusions have been summarized in a rough-draft manuscript proposed for early publication.

Working plans were completed for extensive planting experiments in the spruce type and sites for the various experiments were located and surveyed in preparation for planting. The first plantations in the spruce type were reexamined during the year and a manuscript on the results submitted for publication in the Journal of Forestry. Results of these experiments show the failure of exotic conifers and the superiority of southern balsam fir over all conifers for artificial regeneration in this type. Results from red spruce and red pine planting were fairly satisfactory but second in order of success to southern balsam fir.

Weekly records of the results of direct seeding studies of

(Over)

southern pines in the Piedmont region were kept throughout the growing season of 1939. Although analysis of these data is not complete, it was obvious from general inspection of the experiments that mulching of seed spots is essential on poor, eroded soils.

Plans for next year: Second and third-year growth and survival records for the eight planting experiments in the Appalachian Valley region will be made. Planting will be completed for the various experiments in the spruce type.

Detailed analyses of the direct seeding studies in the Piedmont region will be made and additional tests involving the most successful of these methods will be tried on a more extensive scale.

Date of completion: Project as a whole is continuous. Major objectives of the present direct seeding study in the Piedmont region will be completed by 1942.

First-year survival by various planting methods and species in the spruce type will be available in 1941.

Further developments on early growth and survival of planting experiments on abandoned land in the Appalachian Valley will be issued during 1940.

Assignment: L. S. Minckler, W. E. McQuilkin

RS - AP
REGENERATION
Seed Studies

January 1, 1940

PROJECT STATUS SHEET

Seed Studies

Field division: Forest management research.
Work project: Regeneration.
Line project: Seed studies.
Purpose: To determine the importance of seed source in artificial regeneration.
Review of past work: An extensive experiment to determine the growth of loblolly pine seedlings grown from seed produced by parent trees of various characteristics was established in 1936 at Bonneau, South Carolina, on the Francis Marion National Forest. Although some striking results have already become apparent in growth rates of the various lots of seedlings, this experiment cannot be concluded because it will be flooded by the backwaters of the Santee-Cooper hydro-electric dam.

Tests of the importance of geographical location in the growth and survival of black locust were established in 1936 on the Bent Creek Experimental Forest but few, if any, results will be obtained because of severe browsing by deer.

Accomplishments during past year: Annual examination of the loblolly pine plantations near Bonneau, S. C., was completed.
Plans for next year: Probably the last examination prior to flooding will be made on the loblolly pine plantations at Bonneau, S. C. Whatever results can be obtained from the six annual examinations made to date will be published.

Black locust seed source study plots will be examined and a definite decision made regarding abandonment or continuation of this study. Plans will be formulated for future seed studies.
Date of completion: Project as a whole is continuous. Loblolly pine experiments at Bonneau, S. C., will be completed in 1940.
Assignment: L. S. Minckler.

RS - AP
MENSURATION
Stand Studies

January 1, 1940

PROJECT STATUS SHEET

Stand Studies

Field division: Forest management research.
Work project: Mensuration.
Line project: Stand studies.
Purpose: To determine growth, yield and mortality of forest stands representing the important timber types of the Appalachian Station territory and to develop improved methods of growth, yield and mortality predictions.
Review of past work: Field data for non-normal yield tables for loblolly, shortleaf and Virginia pine have been collected. Non-normal yield tables for loblolly pine pulpwood were completed in final form and much of the preliminary computation for non-normal yield tables for the other two species has also been completed. A new form of yield equation was developed and found applicable to all three species. It simplifies the work necessary for the preparation of non-normal yield tables.

No satisfactory quick method has been devised for determination of growth in the all-aged stands of many species typical of the mountain types. It has been apparent for some time that development of accurate growth predicting techniques for such stands must be based on careful long-time observations of permanent sample plots. Nearly 3,000 such plots were established in 1933 and 1934.

Accomplishments during the past year: Non-normal yield and growth tables for pulpwood stands of loblolly pine were issued in 1939 as Technical Note No. 33.
Plans for next year: Preparation of handbooks of non-normal yield tables for shortleaf and Virginia pine will be commenced.

Five-year reexaminations of the permanent growth plots in mountain hardwood stands will be completed.

Date of completion: Non-normal yield tables for second-growth shortleaf and Virginia pine will be completed in 1941. First results on growth and mortality of all-aged stands of mixed species in mountain types will be completed in 1941.
Assignment: J. H. Buell.

RS - AP
MENSURATION
Tree Studies

January 1, 1940

PROJECT STATUS SHEET

Tree Studies

Field division: Forest management research.
Work project: Mensuration.
Line project: Tree studies.
Purpose: To develop: (1) accurate methods for determining the volume of individual standing trees; (2) factors for converting wood volume from one unit of measure to another, and (3) a tree classification for important timber species.
Review of past work: Cubic-foot and cordwood volume tables and cordwood converting factors for second-growth loblolly pine have been completed.

Board-foot volume tables for important timber species in mountain hardwoods were prepared in 1936 and used by private foresters and in management plan and acquisition surveys in some Southern Appalachian forests. Volume tables showing the amount of cordwood that can be removed from the tops of various species of oak above sawlog utilization have been prepared. Factors for the conversion of oak cordwood into solid cubic feet, units of stacked wood, and board-feet have been completed.

Exploratory studies in tree classification of loblolly pine and white oak have been conducted. It was found that, although a classification for determining the gross increment of individual trees could be made, the ultimate criterion of net value increment could not yet be determined because of inability to forecast the growth of decay and the lumber grade yields of trees of different sizes. Recent work by the Forest Products Laboratory and the Division of Pathology, Bureau of Plant Industry, shows hopeful signs for the solution of these difficulties but has not yet gone far enough to provide data basic for the final solution of tree classification problems.

Accomplishments during the past year: Converting factors and volume tables for loblolly pine pulpwood were completed and incorporated in Technical Note No. 33 released in April, 1939. Factors for the conversion of given volumes of oak cordwood into solid cubic-feet, stacked cordwood, and board-feet, were completed during the year and the first draft of a manuscript prepared for publication. Continual requests for volume tables applicable to given localities resulted in starting a project to construct form class volume tables of the important species of the region. An important feature of the project is to determine which species can be combined into a single table when form class, d.b.h., and merchantable length are recognized in the field. Computations on this project were 30% completed during 1939.

Plans for next year: Completion and publication of form class volume tables for important timber species of the region. Publication of top volume tables for oaks. Publication of converting factors for oak cordwood.

Date of completion: Project as a whole is continuous. See plans for next year for completion of current work.

Assignment: J. H. Buell.

RS - AP
MENSURATION
Statistical Studies

January 1, 1940

PROJECT STATUS SHEET

Statistical Studies

Field division: Forest management research.
Work project: Mensuration.
Line project: Statistical studies.
Purpose: To develop new techniques and methods of expressing the laws of forest growth and measurement.
Review of past work: This project as a whole is inactive and is used primarily as a means to provide an outlet for discoveries made during the conduct of other work. For example: During the exploratory work with white oak tree classification, it was found that so many variables were needed to determine gross increment that tabular or graphic expressions of the classification were too involved for practical use. A pocket-size circular slide rule was developed which simplified the entire procedure. It was also found that this form of slide rule had wide application and could be used for any of the more complicated relationships requiring multiple regression equations for their accurate expression.

Review of instructions for use of the new Abney level showed the existence of large errors in chaining on slopes in excess of Abney readings of 15 or 20.

Accomplishments during the past year: A new set of Abney level correction tables was prepared, applicable for use of either the old or the new Abney level. A valid test for curvilinearity in multiple regression equations was devised and the technique completed for preparation of circular slide rules for any multiple regression equation.
Plans for next year: Manuscript will be prepared and submitted for publication on the tests for curvilinearity in multiple regressions, preparation of circular slide rules for solving multiple regression equations and the set of correction tables for Abney levels.
Date of completion: Project as a whole is continuous. New procedures and techniques in statistical methods will be published as they are developed in connection with other work.
Assignment: J. H. Buell.

RS - AP
FIRE
Control

January 1, 1940

PROJECT STATUS SHEET

Fire Control

Field division: Forest management research.
Work project: Forest fire protection.
Line project: Fire control.
Purpose: To develop methods for determining economic fire control objectives; to determine standards of detection and speed and strength of attack, based upon different degrees of occurrence, visibility, fuel type, inflammability, and potential damage.
Review of past work: Major emphasis has been placed on detection planning, including development of techniques for seen area mapping and lookout-point value compilations, and the development of a haze meter for non-mountainous country. A three-year field study of variations in visibility distance has been completed. Theoretical considerations of visibility problems have been worked out. A new eyesight test for forest lookout men has been finished. The Station has contributed to a regional fuel type classification by report analysis.
Accomplishments during past year: Analysis of haze meter records for three years was completed and a technical note issued. An eyesight test for lookout men was perfected and manuscript prepared for publication. Manuscripts on visibility variations and on a plains haze meter have been accepted for publication. A start was made on comprehensive manuscript on theory and application of visibility and its measurement.
Plans for next year: Completion of manuscript on visibility for Department bulletin. Complete manuscripts on haze, and visual perception of small objects. Analysis of fire reports for the past three years, particularly for purpose of revising fuel type classification. Analysis of fuel type data collected on fires during past three years is also planned.
Date of completion: Manuscripts on visibility subjects - 1940. Analysis of fuel type data - 1940.
Assignment: G. M. Jemison, G, M. Byram.

RS - AP
FIRE
Effects

January 1, 1940

PROJECT STATUS SHEET

Fire Effects

Field division: Forest management research.
Work project: Forest fire protection.
Line project: Fire effects.
Purpose: To ascertain the effect of fire on standing timber, reproduction, other vegetation, and site, in order to furnish information basic to (a) the formulation of sound fire prevention and control plans and policies, (b) the appraisal of fire damage, both tangible and intangible, and (c) the determination of the value of fire as a tool in forest or game management.
Review of past work: Past work has included extensive surveys of tree mortality, mortality and physical damage to vegetation on experimentally burned sample plots, and decay following fire wounding. Recent emphasis has been given to development of techniques of damage appraisal.
Accomplishments during past year: Reexamination of sample plots brought mortality figures up to date. Plan for appraising mortality and cull damage in mountain types was devised and some field work completed. Analysis of data now is under way.
Plans for next year: Continuation of field work assembling data on mortality and cull. Completion of analysis and preparation of damage appraisal tables and report is planned. Study of effect of fire on diameter growth will be continued.

Preliminary analysis of fire effects records for coastal plain controlled-burning plots will be made.

Date of completion: Damage appraisal for mountain forest types - 1940 or 1941. Effect of annual controlled burning on growth and mortality of pine on coastal plain - indefinite. Effect of fire on diameter growth of hardwoods - 1941.
Assignment: G. M. Jemison, J, J. Keetch.

RS - AP
FIRE
Behavior

January 1, 1940

PROJECT STATUS SHEET

Fire Behavior

Field division: Forest management research.
Work project: Forest fire protection.
Line project: Fire behavior.
Purpose: (1) To determine the fundamental laws of ignition and combustion and their application to forest fires and (2) to develop methods of measuring the temporary or fluctuating fire danger variables and of integrating them into numerical ratings so that (a) fire control officers may be able to determine when different types of prevention, detection, and suppression activities are justified, (b) fire prevention and control efficiency may be rated correctly, and (c) fire control may be financed on a sound basis.
Review of past work: Fire danger meters have been developed for mountain and coastal plain regions and are being tested on extensive scale. Studies of solar radiation effects on fuel moisture and studies of fire weather factors, as influenced by altitude and aspect, have been under way for two years.
Accomplishments during past year: Test of the revised mountain type danger meter was extended to about 150 stations from Maine to Arkansas. This included establishment of a network of 45 stations in the New England hurricane area. A coastal plain danger meter was constructed and tests begun at 60 stations from North Carolina to Texas, including a cooperative test with the States of North and South Carolina. Complete analysis has been made of all danger station records. Results were used to check and improve meters and aid in fire control planning. A major publication on the danger rating system was issued as a technical note.

Study of fundamental relation between sun, wind, and fuel moisture was continued and a short manuscript prepared for publication. Six altitude and aspect stations were operated, and a preliminary comparison of fire weather conditions at these stations was made with reference to effects on fire danger.

A manuscript on the Appalachian fuel moisture scales was prepared and has been accepted for publication. Further tests of fuel moisture indicator sticks were conducted and refinements made in their use in moisture measurement.

Theoretical work was carried out on fundamentals of combustion, particularly with reference to application in rating relative inflammability of different fuel types and in rating crown fire danger.
Plans for next year: Continued check of mountain type danger meter and coastal plain meter, particularly as applying to state organizations. Analysis of fire reports to establish rates of spread by danger classes. The study of fire weather, as influenced by altitude and aspect, will be continued. Investigations of relation of radiation and wind to fuel moisture will be finished and manuscript prepared. Theoretical considerations of fundamentals of combustion and inflammability will be continued.
Date of completion: Check of fire danger meter and extension of its use to other agencies - indefinite. Analysis of fire reports - 1940. Altitude and aspect study - 1944. Solar radiation - fuel moisture study - 1940. Combustion and inflammability - indefinite.
Assignment: G. M. Jemison, G. M. Byram.

RI - AP
CLIMATE
Forests

January 1, 1940

PROJECT STATUS SHEET

Local Effect of Forests on Climate

Field division: Forest influences research.
Work project: Effect of cover on climate.
Line project: Local effect of forests on climate.
Purpose: To determine the influence of forest vegetation upon the meteorological conditions of its immediate environment.
Review of past work: All meteorological records now being obtained as a part of the Station's watershed studies have furnished basic data for analysis of possible vegetation effects. Stream runoff records from drainages having different aspects have shown that temperature and aspect are proving to be factors of major importance in water yield, indicating that still more intensive study of microclimatics must be covered as a part of drainage area studies.

Within the Copper Basin (Tennessee) six first-order meteorological stations are in operation, two in each of the three major vegetation zones of the area. Three of these stations were installed in 1934, the remainder in 1936. An additional 24 standard rain gages are being operated in the locality by the Hydrologic Data Division of the T.V.A. and by the Station. All of the above records are being compiled and kept up to date.

Accomplishments during past year: Present installations have been maintained. Four years' complete records from the Class A meteorological stations within the major vegetation zones of the Copper Basin have been compiled and a beginning made on preparation of a manuscript on the result of the investigation to date.
Plans for next year: Complete Copper Basin manuscript. Supplement drainage area studies, particularly at Coweeta, with better indices for evaporation and transpiration. If Copper Basin station is continued, work there will be expanded to include meteorological records inside tree plantations.
Date of completion: Continuous.
Assignment: C. R. Hursh.

RI - AP
STREAMFLOW
Forest

January 1, 1940

PROJECT STATUS SHEET

Relation of Forest Cover to Streamflow

Field division: Forest influences research.

Work project: Influence of natural vegetation on streamflow.

Line project: Relation of forest cover to streamflow.

Purpose: To determine the effects of forestry practices and forest land management upon the yield and quality of stream water.

Forest land management in the Southern Appalachian region in the broad sense, includes cutting systems for the removal of wood products, woodland grazing, fire protection, planting, mountain farming, and denudation by smelter fumes. These land-use practices will be included in the studies.

Review of past work: Drainage area studies were begun in 1934 in the three major rainfall zones of the Southern Appalachian Mountains. The work to date, a primary phase of the project, has been restricted to standardization of drainages for future comparisons after the present vegetative cover conditions have been altered to represent different kinds of forest land management.

Accomplishments during the past year: The primary period of standardization of drainage areas has served admirably to define small drainage area-streamflow characteristics for the region. Some of these characteristics have been presented in two formal reports during the year and appeared in the Journals of the American Society of Civil Engineers. Analysis of runoff and precipitation records have been completed for most of the drainages under consideration. For the first time, data are available on which it is possible to determine the water economy of small drainages with sufficient precision that the standardization phase may be considered to have been completed.

Plans for next year: Of the 40 drainage areas under observation in all rainfall zones, approximately 18 appear to be standardized sufficiently to proceed with the second phase of the study. A special conference will be called early in the year to decide upon correct technics for proceeding with the study. Subsequently, the treatments of the cover conditions decided upon will be carried out -- beginning at the Coweeta Experimental Forest.

A five-year progress report of the project is being assembled. In addition, a formal technical paper will be prepared on the subject of the water economy of the drainage areas under observation.

Date of completion: Continuous.

Assignment: C. R. Hursh, M. D. Hoover, J. M. Rosa.

RI - AP
SOIL STABILIZATION
Roadbanks

January 1, 1940

PROJECT STATUS SHEET

Roadbank Stabilization

Field division: Forest influences research.
Work project: Stabilization of soil.
Line project: Roadbank stabilization.
Purpose: To determine practical methods of permanently stabilizing roadbanks.
Review of past work: Beginning in 1934, the Station has conducted a series of studies covering the practical aspects of roadbank stabilization. Basic principles of vegetation establishment have been found and demonstration areas of successful roadbank control are now available in every section of the Station's territory.
Accomplishments during the past year: The Station was called upon to serve in advisory and personnel training capacity for numerous cases of roadbank control by state highway departments, national forests, and private citizens. A third progress report on low-cost roadbank stabilization was published as Station Technical Note No. 38.

A new series of seeding and fertilizing tests was started to determine suitable species, amount of seed, and time of year to obtain quick vegetative growth under different stabilization practices.
Plans for next year: Field counts of plant survival for the seeding and fertilizing tests of 1939 will be made. Additional fertilizer tests using calcium metaphosphate furnished by the Tennessee Valley Authority, will be carried out on the Coweeta Experimental Forest. A general review of all roadbank studies to date will be published. Considerable time probably will have to be spent on technical advisory jobs.
Date of completion: Continuous.
Assignment: E. D. Marshall.

RI - AP
WATER UTILIZATION
Forests

January 1, 1940

PROJECT STATUS SHEET

Transpiration and Other Consumptive Uses of Water by Forest Cover

Field division: Forest influences research.
Work project: Water utilization by vegetation.
Line project: Interception, transpiration and ground water.
Purpose: To determine the effect of forest cover as related to canopy interception of rainfall, to transpiration, and to other consumptive use forms of water. This project also embraces the study of the effects of trees upon soil moisture and ground water.
Review of past work: A study of the interception of precipitation by tree canopies has been completed for four representative forest types in the 40-inch rainfall zone on the Bent Creek Experimental Forest. A report on this study has been in manuscript form for the past year. A second study of canopy interception was begun in the 70-inch rainfall zone on the Coweeta Experimental Forest in 1938.

No direct studies of transpiration have been undertaken. Methods for determining transpiration from seasonal stream depletion curves and from diurnal fluctuation in streams and wells have been investigated as to their usefulness.

The measurement of the height of the water table in experimental wells has been carried on as a step in the analysis of the stream hydrograph. However, these same records serve in estimating seasonal changes in the water storage factor for individual drainage area and, as such, are valuable in the analysis of consumptive uses of water.

Plans for next year: Expedite the review of the original canopy interception report for publication. Field records will be continued on the Coweeta Experimental Forest.

The transpiration study will remain an orientation study of methods for another year. The study of ground water will continue in its present status.

Date of completion: Continuous.
Assignment: C. R. Hursh, E. D. Marshall.

RI - AP
FLOOD CONTROL
Preliminary Examinations

January 1, 1940

PROJECT STATUS SHEET

Preliminary Flood Control Examinations

Field division: Forest influences research.
Work project: Flood control surveys.
Line project: Preliminary flood control examinations.
Purpose: Examination of watersheds to determine existence of flood problems, the feasibility of flood control by the Department of Agriculture, and to locate the critical silt and flood source areas.
Review of past work: The Department of Agriculture was first authorized to participate in flood control surveys by Section 6 of the Flood Control Act of June 22, 1936 (Public 738 - 74th Congress). Active work was, however, delayed until June, 1937, when funds were first made available. During 1937 the Station cooperated in preparing the preliminary report on the Pee Dee watershed in North Carolina, South Carolina and Virginia. In 1938 the preliminary report on the Potomac watershed in Virginia, West Virginia, Maryland, Pennsylvania, and the District of Columbia, was completed under Station chairmanship. In 1938 some work was done on the preliminary report for the New River (above the site of the Bluestone Flood Control Reservoir) Big Sandy, Little Kanawha, James, Smith, Roanoke, and Kanawha watersheds. The Station also assisted in obtaining data for the preliminary reports on the Santee-Cooper, Tar-Neuse and Cape Fear watersheds.
Accomplishments during past year: On watersheds for which this Station functions as chairman of the Field Committee, the preliminary report on the New River (above the Bluestone flood control dam site) was completed and work was continued on the preliminary reports for the Big Sandy and Little Kanawha watersheds.

On watersheds for which this Station functions as a member of the Field Committees, the preliminary report was completed for the Santee-Cooper watershed.

Plans for next year: During 1940 the preliminary reports will be completed for the Big Sandy and Little Kanawha watersheds and work will be started on the James and Tennessee watersheds.
Date of completion: Indefinite.
Assignment: H. C. Woster.

RI - AP
FLOOD CONTROL
Watershed Surveys

January 1, 1940

PROJECT STATUS SHEET

Watershed Surveys

Field division: Forest influences research.
Work project: Flood control surveys.
Line project: Watershed surveys.
Purpose: Detailed field surveys of approved watersheds to determine the conservation or minor engineering measures needed to retard runoff and control soil erosion for flood control, to determine a plan for putting these measures into effect and to determine their economic feasibility.
Review of past work: In 1938 the Station cooperated in a survey of the Coosa River watershed above Rome, Georgia, an area of approximately 4,000 square miles.
Accomplishment during past year: The survey of the Coosa River watershed was completed in September, 1939. The Station prepared a Survey Work Outline for the Potomac watershed and began a survey on this watershed in October, 1939. The Station also assisted in preparing a Survey Work Outline for the Pee Dee watershed and cooperated in a survey of this watershed started in October, 1939.
Plans for next year: The Survey Work Outline for the New River will be completed. Additional work depends on action taken by the Flood Control Advisory Committee in Washington.
Date of completion: Pee Dee Survey, December, 1940; Potomac Survey, February, 1941.
Assignment: H. J. Loughead, A. L. Richey, M. M. Bryan.

RE - AP
FOREST SURVEY
Drain

January 1, 1940

PROJECT STATUS SHEET

Forest Survey - Drain Phase

Field division: Forest economics.
Work project: Survey of forest resources.
Line project: Drain.
Purpose: To determine the rate at which the forest is being diminished through industrial and domestic use.
Review of past work: A mill-to-mill canvass of the forest industries was completed in South Carolina in 1937 and in North Carolina in 1938 to obtain a record of timber consumption by these industries. Compilation of the drain data for South Carolina for 1936 was completed and for North Carolina was well under way by the end of the year.

At the request of the Bureau of the Census copies of the individual mill records obtained by the Survey in North Carolina were sent to the Bureau to supplement their own information. The Bureau was also sent a complete list of the sawmills in South Carolina for use in mailing questionnaires for the 1938 census of lumber production.

Accomplishments during the past year: A cooperative agreement was made with the Bureau of the Census whereby the 1938 Census questionnaires for North Carolina were edited and corrected in the Survey office. A field canvass was made of sawmills not replying to the Census questionnaire and at the same time information was gathered on the wood consumption of non-lumber industries in the state.

Non-lumber industries in South Carolina were also visited during the year to obtain reports for 1937 and 1938. The sawmill drain for these years was obtained from the Bureau of Census records supplemented by visits to a number of the larger mills.

Plans for next year: The cooperative Census agreement has been extended to include both North and South Carolina so that over three thousand forms will be received for editing and correction. No field work is contemplated unless the Census field agents fail to contact all wood using industries.

During the year all drain data for North and South Carolina will be brought up to date so that comparisons can be made with current growth estimates.

Date of completion: Continuous.
Assignment: G. E. Morrill, T. C. Evans.

RE - AP
FOREST SURVEY
Growth and Yield

January 1, 1940

PROJECT STATUS SHEET

Forest Survey -- Growth and Yield Phase

Field division: Forest economics.
Work project: Survey of forest resources.
Line project: Growth and yield.
Purpose: To determine the current and probable future rate of timber growth and the productive capacity of the forest area.
Review of past work: Growth computations for the South Carolina units were completed in 1938 for the year 1936 and the machine tabulations of growth data were made for the three eastern North Carolina units.
Accomplishments during the past year: Machine tabulations for the mountain unit of North Carolina were made and growth percents computed. Growth computations for the three eastern units of the state were completed.
Plans for next year: Growth computations for the South Carolina units for the years 1937 and 1938 will be made as will those for all North Carolina units for 1938. Growth work for the Virginia units will be pushed as rapidly as field progress permits.
Date of completion: Continuous.
Assignment: G. E. Morrill, T. C. Evans.

RE - AP
FOREST SURVEY
Inventory

January 1, 1940

PROJECT STATUS SHEET

Forest Survey -- Inventory Phase

Field division: Forest economics.
Work project: Survey of forest resources.
Line project: Inventory.
Purpose: To determine the extent, location, and condition of forest lands in the Station's territory and the quantity, kinds, quality, and availability of timber now standing on these lands.
Review of past work: The Forest Survey organization was established at this Station in April, 1936. Field work was begun in July of that year but was discontinued for the period from December, 1937, to June, 1938. By November, 1939, when the field organization was again disbanded, all of South Carolina not previously covered by the Southern Station and all of North Carolina had been completed; a total of 45 million acres. There remained nearly 65 million acres in Virginia, West Virginia, Tennessee, and Kentucky to be completed.

Basic tables of area and volume were completed for two South Carolina units in 1937 and for all except the mountain unit of North Carolina during 1938.

Accomplishments during past year: No additional field work was done during the year.

Basic tables of area and volume were completed for the mountain unit of North Carolina. State tables of area and volume were compiled for South Carolina.

Plans for the next year: Field work will be resumed in the coastal unit of Virginia early in March and will be extended into the Piedmont area of the state so far as available funds permit.

Consolidated tables of area and volume will be compiled for North Carolina for use in preparing the state report. Tables for the Virginia units will be computed as soon as possible after field work is completed.

Date of completion: Indefinite.
Assignment: E. V. Roberts, J. Carow, G. E. Morrill, T. C. Evans.

RE - AP
FOREST SURVEY
Reports

January 1, 1940

PROJECT STATUS SHEET

Forest Survey -- Report Phase

Field division: Forest economics.
Work project: Survey of forest resources.
Line project: Reports.
Purpose: Analysis and interpretation of data and preparation of reports.
Review of past work: Analysis of the data of South Carolina Survey units was completed and the preliminary drafts of the unit reports were prepared. A special compilation of Survey data was made for a group of 10 counties in the Central South Carolina Project as a basis for the analysis of forest conditions in this area.
Accomplishments during the past year: The reports for the three Survey units in South Carolina were completed and published during the year under the following titles:

Forest Survey Release No. 1, "Forest Resources of the Northern Coastal Plain of South Carolina".
Forest Survey Release No. 2, "Forest Resources of the Piedmont Region of South Carolina".
Forest Survey Release No. 3, "Forest Resources of the Southern Coastal Plain of South Carolina".

The first draft of the South Carolina State Report was completed. Analysis of the field data was completed for Units 1, 2, and 3 in North Carolina. The report for Unit No. 1 was completed and circulated for review and the report for Unit No. 2 was about 80 percent completed.

Plans for next year: Completion of the South Carolina State Report, the remaining unit reports of North Carolina and the first draft of the North Carolina State Report are planned for 1940.
Date of completion: Indefinite.
Assignment: J. W. Cruikshank, E. V. Roberts.